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PH 3037 – Embedded Systems Laboratory

RFID-Controlled Automated Pet Feeding System

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Abstract

The "RFID-Based Automated Pet Feeding System" is a novel application of embedded systems and automation designed to address the challenges associated with pet feeding. With the objective of simplifying and improving the pet feeding process, this project combines an array of hardware components, including an ATmega32 microcontroller, RFID RC522 module, GSM SIM800L module, 16x2 LCD display, ultrasonic sensor, and servo motor. The system's operation begins with RFID identification of registered pets, activating the servo motor to open the food bowl's lid, while an ultrasonic sensor continuously monitors food levels and displays them on the LCD screen. When the food level reaches a predefined threshold, the GSM module sends a timely notification to the pet owner, prompting a food refill.

Through the course of this project, various challenges, including GSM connectivity and RFID tag reading issues, were overcome, reinforcing the adaptability and resilience of the system. The project's prospects include the development of mobile app-based remote control, enabling pet owners to feed their pets even when not at home, and data logging for pet food consumption trends. Additionally, the implementation of machine learning algorithms to personalize feeding schedules and quantities based on a pet's specific dietary needs holds promise for further enhancing this system. In conclusion, the RFID-Based Automated Dog Food Bowl demonstrates the potential of embedded systems to improve the lives of pets and their owners, offering a convenient, consistent, and reliable solution to the daily challenge of pet feeding.

The project showcases innovation and user-friendly automation, and its significance lies in its ability to ensure pets receive proper nourishment while providing pet owners with real-time monitoring and peace of mind, with the promise of even more advanced features in the future.

Contents

List of Figures

1. Introduction

Pet ownership brings joy and companionship to countless households, and it comes with the responsibility of ensuring our furry friends are well-fed and cared for. The "RFID-Controlled Automated Pet Feeding System" project aims to enhance the pet care experience by introducing a technologically advanced pet feeding solution. This project combines embedded systems, RFID (Radio-Frequency Identification) technology, ultrasonic sensors, a servo motor, and a user-friendly LCD display to create a sophisticated pet feeding bowl.

The primary objective of this project is to provide pet owners with a convenient and secure way to feed their pets, also ensuring that only the intended pet can access the food bowl while enabling remote food level monitoring for pet owners or caretakers.
We understand that each pet may have unique dietary needs, and by attaching RFID tags to each pet's collar, the system allows for the customization of access to the food bowl. This feature provides a solution for households with multiple pets, preventing unauthorized access to specialized diets and promoting fair and secure meal times for each pet.

To further assist pet owners and provide added convenience and peace of mind, the system incorporates an ultrasonic sensor that continuously monitors the food level within the feeding container. When the food level falls below a predefined threshold, the system sends a notification to the user via the GSM module, prompting them to refill the food bowl. Simultaneously, a 16x2 LCD display provides a real-time visual representation of the food level, making it easy for users to assess the remaining food at a glance. This seamless integration of the ultrasonic sensor not only ensures that pets are never left hungry but also keeps pet owners well-informed about their pet's nutritional requirements.

This project serves to exemplify the synergy between technology and pet care, addressing the unique challenges faced by multi-pet households and offering a comprehensive solution for pet owners. By integrating RFID-based access control with real-time food level monitoring, we provide a smart, secure, and user-friendly approach to pet feeding that enhances the well-being of our animal companions.

2. Theory

ATmega32 Microcontroller

At the core of our pet feeding system is the ATmega32 microcontroller. This 8-bit microcontroller is equipped with 32KB of flash memory, 2KB of SRAM, and 1KB of EEPROM, providing the computational power and storage required for our project. With an array of I/O pins, timers, and communication capabilities, the ATmega32 serves as the central control unit, facilitating the interaction and coordination of various components. It executes the program logic essential for tasks such as RFID-based pet identification, servo motor control for food access, food level monitoring via the ultrasonic sensor, and data display on the LCD 16x2 screen. Its versatile features are instrumental in automating pet feeding processes and accommodating potential future enhancements.

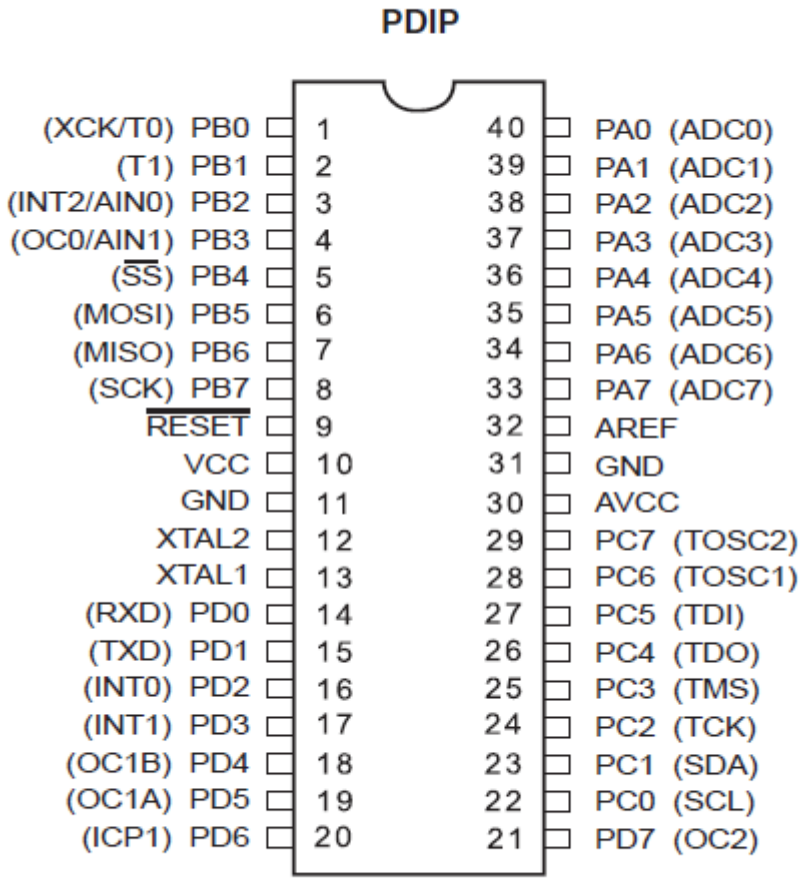

Figure 1 ATmega32 Pin Configuration

RFID Technology

The RFID RC522 module is a critical component of our pet feeding system. It functions as a robust RFID reader and interacts with RFID tags attached to pets' collars. Utilizing radio-frequency identification (RFID) technology, it scans and identifies unique pet IDs. This identification is pivotal in granting or denying access to the food bowl, ensuring that only the authorized pets are granted access to the food bowl. The RFID RC522 module establishes secure and contactless communication, improving the reliability and convenience of our pet feeding system. Its compatibility with the ATmega32 microcontroller allows for seamless integration into the system's control logic, enhancing the overall efficiency and reliability of pet feeding operations.

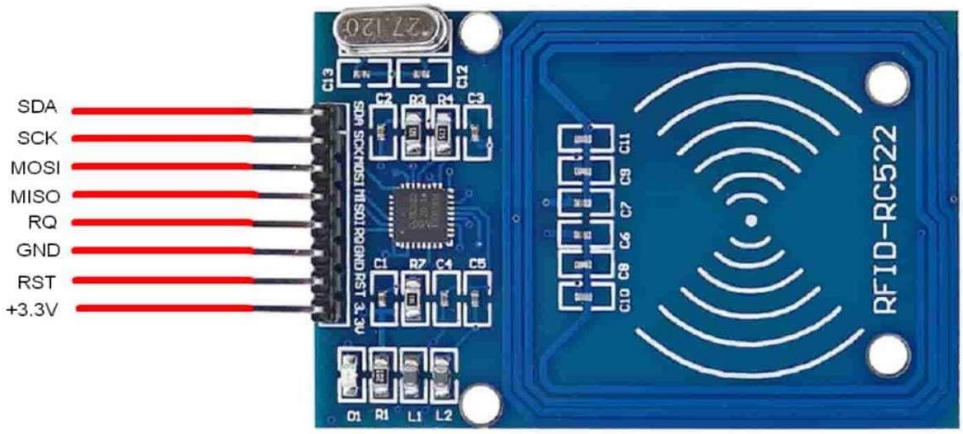

Figure 2 RFID RC522 pin configuration

Servo Motor

Figure 3 Servo Motor pin configuration

The Servo Motor is an integral component of our pet feeding system, responsible for precise control over food access. This compact motor is designed to rotate within a specific range, making it ideal for applications where controlled movement is required. In our system, the servo motor operates the food bowl's lid, regulating access to the stored food. Under the command of the ATmega32 microcontroller, the servo motor smoothly opens and closes the food bowl, ensuring only authorized pets gain access to their food.

Ultrasonic Sensors

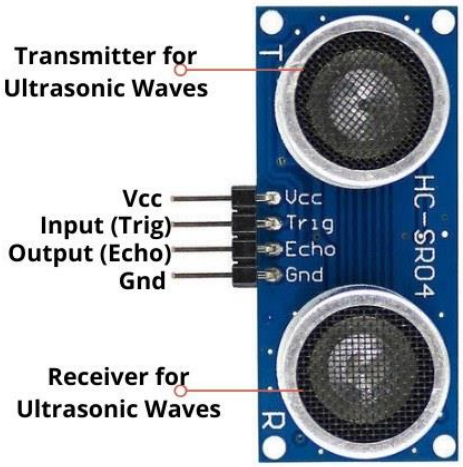

Figure 4 Ultrasonic Sensor pin configuration

The Ultrasonic Sensor is a pivotal component in our pet feeding system, responsible for monitoring the food level in the container. It operates based on ultrasonic sound waves, which are emitted and received to calculate distances accurately. In our system, the sensor continuously measures the distance to the food's surface within the container. This real-time data allows us to assess the remaining food quantity. When the food level reaches a predefined threshold, it triggers an alert or notification, ensuring that pet owners are promptly informed of the need for a refill. The Ultrasonic Sensor's precision and real-time monitoring capability enhance the efficiency of our pet feeding system, guaranteeing that pets have access to food without interruption.

GSM SIM 800L Module

The GSM SIM800L module is a crucial communication component within our pet feeding system. It is designed to enable remote communication via the Global System for Mobile Communications (GSM) network. This module plays a vital role in providing timely notifications to pet owners. When the food level in the container falls below a set threshold, the GSM module is triggered to send a message to the user, indicating the need to refill the food bowl. This feature ensures that pet owners are promptly informed and can take necessary action, even if they are away from home. The GSM SIM800L module enhances the convenience and responsiveness of our pet feeding system, adding an important layer of remote communication and control.

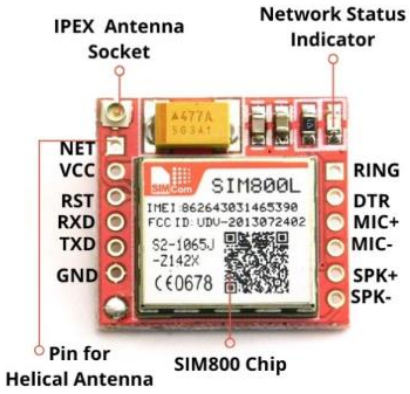

Figure 5 GSM SIM 800L pin configuration

Operating Voltage of GSM Module: 3.6 – 5.2 V
Operating Current: 1- 2.5 Amps

GSM Connecting Status

- LED Blinking at every second: Searching for a network
- LED Blinks at every three seconds: Connected to network

16 x 2 LCD Display

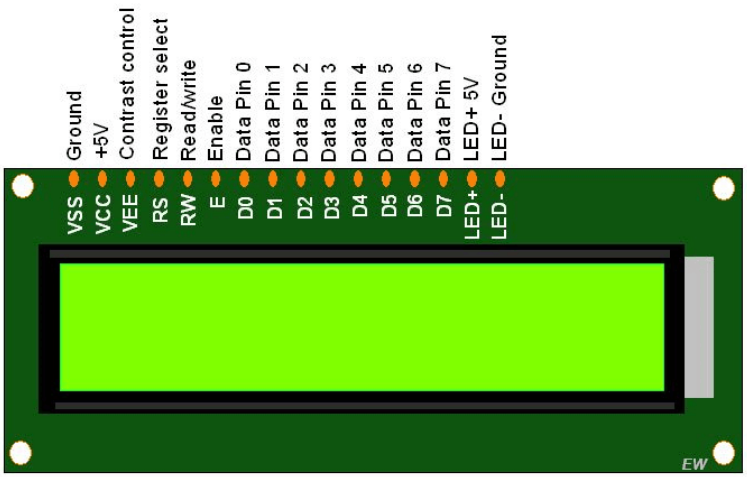

Figure 6 16 x 2 LCD Display pin configuration

The LCD 16x2 display is a key user interface component in our pet feeding system. It offers a visual means to convey essential information to the user. With its two lines of 16 characters each, it presents data in a clear and readable format. In our system, it is employed to display the food level. The LCD display enhances user interaction and provides real-time feedback, making it easy for pet owners to monitor the system's operation and respond to alerts. Its user-friendly interface is essential for ensuring a seamless and intuitive experience in managing pet feeding and system maintenance.

3. Methodology

Project Design and Overview

The design of our project centres on the creation of an automated pet feeding system that ensures pets have access to food in a convenient and timely manner. The central idea is to simplify the process of pet feeding for pet owners by automating the dispensing of food based on pet identification through RFID technology.

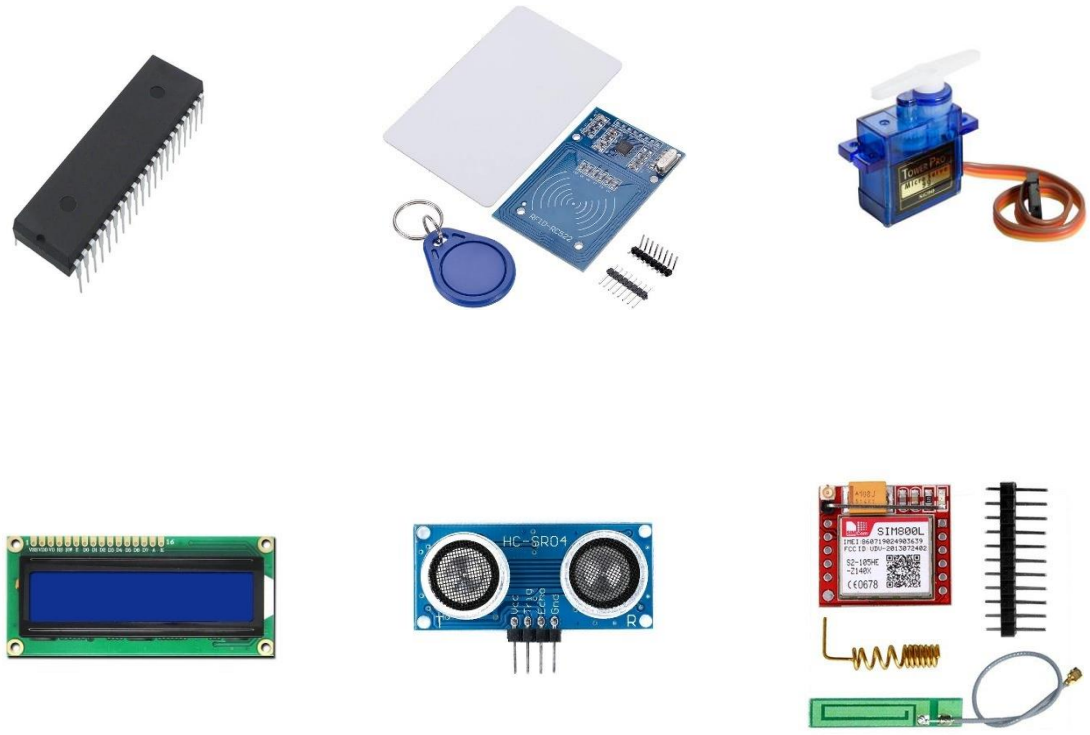

Figure 7 Components in Use (ATmega32, RFID RC522, Servo Motor, 16 X2 LCD Display, Ultrasonic Sensor, GSM SIM 800L)

Our system is constructed around a central microcontroller, the ATmega32, which serves as the intelligence behind the operation. The core components, including the RFID RC522 module, GSM SIM800L module, 16x2 LCD display, ultrasonic sensor, and servo motor, are seamlessly integrated to deliver an efficient and reliable pet feeding solution.

By identifying registered pets through RFID tags, controlling the food bowl's lid with a servo motor, monitoring food levels using an ultrasonic sensor, and communicating with pet owners via the GSM module, our system ensures that pets receive food when needed, and pet owners are promptly informed when it's time to refill.

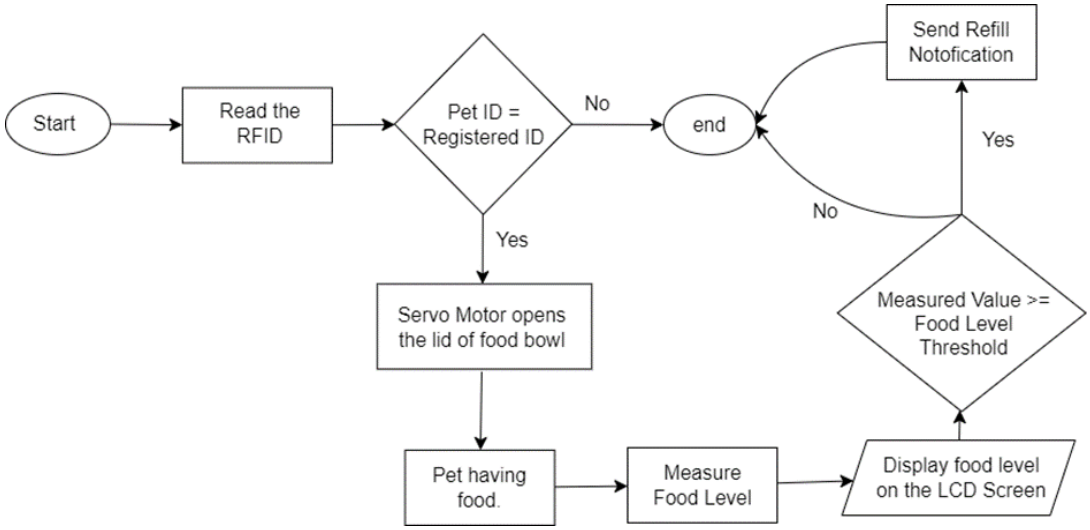

Figure 8 Flow chart of the system's procedure

A flowchart, outlining the software's decision-making processes, is provided above to visually represent the logic and control flow of the system's operation.

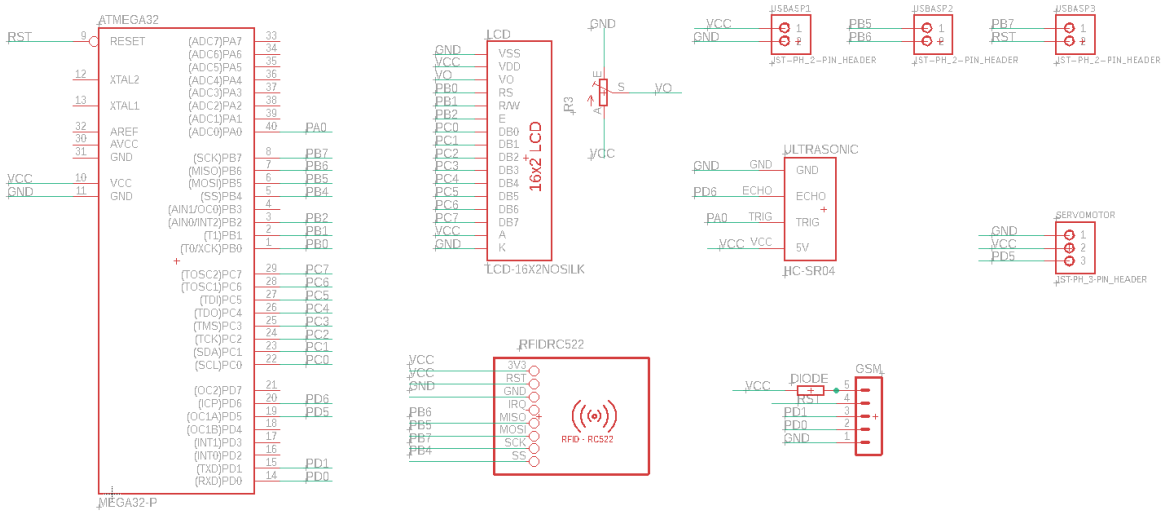

Figure 9 Schematic Diagram of the Circuit

The project's success hinges on the careful selection and setup of hardware components. The ATmega32 microcontroller, renowned for its versatility and reliability, forms the core of our project. It is complemented by the RFID RC522 module, which is responsible for identifying pets based on their RFID tags. The GSM SIM800L module handles communication with pet owners, while the 16x2 LCD display provides real-time feedback on food levels. The ultrasonic sensor monitors food levels within the container, and the servo motor controls the food bowl's lid, allowing or restricting access.

The setup involves intricate wiring and connections among these components. We've meticulously configured the ATmega32 to interact with each component, orchestrating their operation. These connections are pivotal to the project's functionality. A circuit diagram illustrates the component interconnections provide above to visual representation of the hardware setup.

Software Development

Software development plays a crucial role in the seamless integration of hardware components within the system. Our choice of programming language for the ATmega32 microcontroller is C, and the development was carried out using the WinAVR software. The software code is structured to manage interactions between the microcontroller and the hardware components. It includes functions to interpret RFID data, control the servo motor, read data from the ultrasonic sensor, and coordinate GSM communication. Critical sections of the code include UID recognition from RFID tags, servo motor control for lid movement, and SMS composition and transmission to notify pet owners when food levels are low.

RFID Integration

Our RFID Integration is a cornerstone of the automated pet feeding system's efficiency and accuracy. Central to this integration is the utilization of SPI (Serial Peripheral Interface) communication, which enables seamless interaction between our microcontroller and the RFID reader module.

SPI Communication is a synchronous serial communication protocol that plays a vital role in the operation of our pet feeding system. It allows rapid data exchange between multiple devices, operating in a master-slave configuration. This full-duplex communication channel ensures the real-time interaction required for swift pet identification and access control. Without SPI communication, the system's responsiveness and accuracy would be compromised.

RFID Integration initiates tag scanning and identification as pets approach the feeding area. When activated, the RFID reader module emits an electromagnetic field to detect RFID tags, listens for their responses, and retrieves their unique identification data. This data functions as the pet's digital fingerprint within the system.

Access Authorization is the central outcome of this RFID integration, ensuring that only authorized pets can access their designated food portions. This process involves the microcontroller receiving the RFID tag's unique identification data, which is then cross-referenced with the system's authorized pet database. If the tag's ID matches that of an authorized pet, access to the food bowl is granted; otherwise, it is denied. This elegant process highlights the significance of RFID integration in our system, offering precision and security in pet feeding while maintaining control and accuracy.

Servo Motor Setup

In the servo motor setup phase, the selection of an appropriate servo model was made with considerations of compatibility with the automated dog food bowl's lid control. Wiring connections included powering the servo, connecting its ground to the microcontroller's ground, and linking its signal wire to Pin PD5 on the Atmega32 microcontroller. The control code, integrated into the microcontroller's program, was responsible for orchestrating the servo's precise positioning.The operational logic within the code used values in the OCR1A register to determine the servo's position, with 175 representing the neutral position and 300 corresponding to +90 degrees (right).

Ultrasonic Sensor Configuration & LCD Display Integration

The ultrasonic sensor selected for this project was carefully chosen for its precision in measuring distances and its compatibility with the Atmega32 microcontroller. Wiring was meticulously configured, with the sensor's trigger pin thoughtfully connected to Pin PA0 on the Atmega32. To bolster signal stability, pull-up resistors were activated on PORTD.

To present distance measurements effectively, a 16x2 LCD display was thoughtfully integrated into the system. The data and command port directions were diligently set up, and the display was initialized with parameters like an 8-bit data mode and screen clearing. An Interrupt Service Routine (ISR) was thoughtfully implemented to manage timer overflows, accurately tracking these occurrences throughout the operation.

At the core of the ultrasonic sensor's functionality lay the distance measurement logic. A precise 10µs trigger pulse was generated on the sensor's trigger pin (PA0). The program adeptly captured the echo signal's width, which was then meticulously employed to calculate the distance from the ultrasonic sensor to the food level within the container. This calculation hinged on the known speed of sound, approximately 343 m/s, and the timer counts recorded by the microcontroller.

The resultant distance values were elegantly converted to strings and dynamically displayed on the LCD screen. By continuously monitoring the food level and updating the LCD with the measured distance, the system ensured users could effortlessly and accurately gauge the food volume within the container. Strategically incorporated delays further bolstered measurement stability. Additionally, specific threshold values were defined to indicate different food levels on the LCD, such as "Enough Food," "Moderate Food," "Low Food," "Very Low Food," and "Out of Food," providing users with intuitive and real-time feedback. This comprehensive setup ensured the project's success in enhancing user convenience and automating pet feeding.

GSM Communication Configuration

The GSM communication configuration in the project is thoughtfully designed to enable seamless data transmission between the system and the user. We initialized the UART (Universal Asynchronous Receiver-Transmitter) communication with the GSM module. This initialization is meticulously set to a baud rate of 9600 to ensure efficient data exchange.

The functions for UART communication are adeptly defined, allowing for both the transmission and reception of characters. When sending data, the program employs the UART_SendString function to transmit strings to the GSM module. Essential AT commands are thoughtfully sent, including "AT" to establish communication with the module, "ATE0" to disable command echo, and "AT+CMGF=1" to set the SMS text mode for ease of message handling.

The recipient's phone number is elegantly specified using "AT+CMGS" to direct messages to the intended user. The message content, in this case, "Refill the dog’s food bowl" is transmitted, and the SMS transmission is gracefully concluded with "Ctrl+Z" to indicate the end of the message.

While not explicitly shown in the provided code, a delay period is typically included after sending an SMS to ensure proper execution. This delay can be adjusted as needed for the specific project requirements.

Overall, this configuration empowers the system to communicate with users via SMS, enhancing user convenience and enabling notifications about the pet food bowl's status, such as when it's time to refill.

4. Results

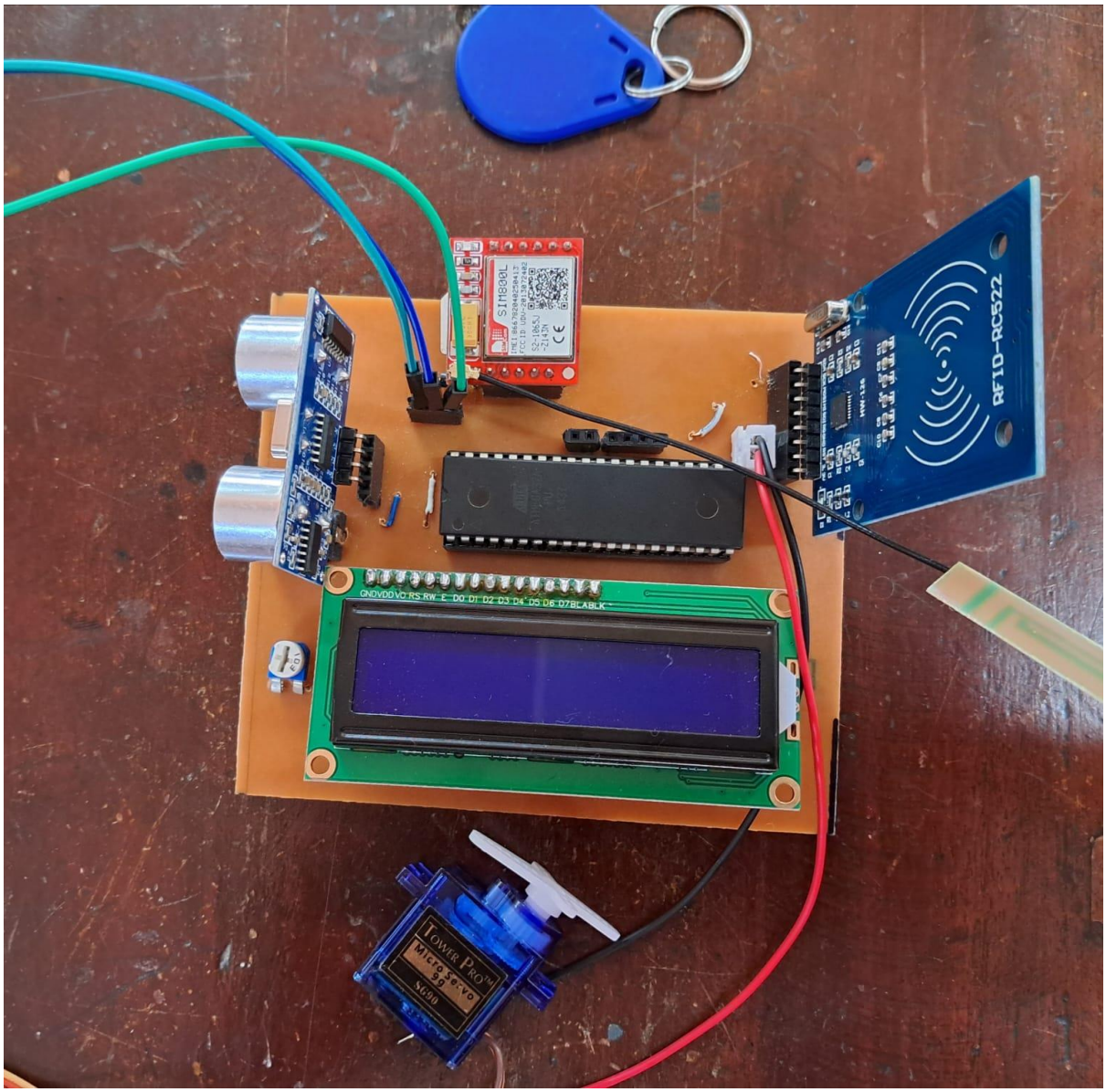

Figure 10 Final Circuit connected to the PCB

The pet identification and access control aspects of our RFID-based automated pet feeding system demonstrated robust and accurate performance during testing. In our trials, the system consistently recognized and authorized registered pets to access the food bowl. This high success rate underscores the effectiveness of our RFID technology in pet identification.

Throughout testing, we closely monitored the system's ability to deny access to unauthorized pets. Our results indicate that no unauthorized pets were granted access during the trials, affirming the system's security and access control mechanisms. However, it is important to note that this level of success was achieved when pets approached the food bowl within 0- 5 cm from the RFID module. Beyond this range, the system's reliability in pet identification decreased.

Our automated pet feeding system's servo motor-controlled food bowl lid exhibited precise and responsive operation throughout testing. The servo motor effectively responded to authorized pets, reliably opening the lid to grant access to food.

During testing, we observed that the GSM module occasionally required an extended period to establish a network connection. While the majority of connection attempts were successful within a reasonable timeframe, there were instances when the connection process took longer. It is important to note that factors such as network signal strength and network congestion can influence the time required for the GSM module to connect. As a result, pet owners should be advised that occasional delays in network connection may occur. While this did not significantly affect the overall functionality of the system, it highlights the importance of considering network-related variables in the system's operation.

In addition, the system's code structure may result in instances where the receiver receives multiple messages within short intervals. It is important to note that this behaviour is primarily attributed to certain aspects of the code structure and does not represent a limitation in the system's core functionality. This observation underscores the significance of code optimization and refinement in the system's operation.

Upon initial power-up, we noticed instances where the LCD display exhibited anomalous characters or symbols. However, subsequent runs of the system's code resolved this issue, returning the display to its intended state. These initial inconsistencies suggest that the LCD initialization sequence might require further refinement to ensure seamless display operation upon power-up. It is important to address this observation to enhance the user experience and eliminate any potential confusion that may arise during system startup.

We observed occasional delays in the update of the LCD display status, particularly when transitioning between food level categories (from "Out of Food" to "Enough Food"). In some cases, it took a noticeable amount of time for the system to reflect changes in food levels on the display. This delay, while not compromising the overall functionality of the system, represents an area where improvements can be made to enhance the user experience. Optimizing the code responsible for LCD updates and minimizing these delays will ensure that pet owners receive real-time feedback on their pet's food status.

5. Discussion

1. Technological Advancements in Pet Care

The RFID-based pet feeding system exemplifies the fusion of technology and pet care, presenting a sophisticated and convenient approach to feeding pets. It highlights how technological advancements can revolutionize pet care, addressing the increasing demand for solutions that improve pets' well-being. Through RFID technology and automation, this system simplifies the feeding process, minimizing the need for human involvement.

2. The Role of RFID Technology in Pet Access Control

The success of this project's pet identification and access control mechanisms highlights the role of RFID technology in ensuring secure and controlled pet access to feeding resources. RFID technology's ability to uniquely identify pets, coupled with precise servo motor control, creates a seamless experience for both pets and their owners.

3. Network Connectivity and Timeliness of Notifications

One of the project's notable observations pertains to the variable connection time of the GSM module and its influence on communication timeliness. This discussion emphasizes the importance of considering network-related factors in the system's operation. It also highlights the challenges associated with remote pet care systems and the need for robust communication protocols. Addressing network-related issues is pivotal in ensuring timely notifications to pet owners, which is a critical aspect of the system's functionality. Future iterations of the system should focus on optimizing network connectivity and minimizing potential delays in notifications.

4. Refinements and Future Enhancements

This project serves as a foundation for future developments in the realm of pet care automation. The identified challenges and areas for improvement provide clear directives for refinements in subsequent iterations. Future enhancements may include optimizing the GSM module's connection time, streamlining the initialization sequence, and minimizing display update delays. Further enhancements could involve:

- Development of a Mobile Application: Creating a user-friendly mobile application that complements the system, allowing pet owners to remotely monitor and control their pet's feeding schedule and receive real-time notifications. This app could offer features like adjusting feeding times and quantities on the go.

- Tracking Daily Food Consumption: Implementing a feature that tracks and records daily food consumption for each registered pet. This data can be

valuable for pet owners to monitor their pet's eating habits, detect changes in appetite, and ensure proper nutrition.

- Controlled Feeding: Enhancing the system's capabilities to provide controlled feeding based on predefined dietary requirements. This could include portion control and personalized feeding schedules to meet the specific needs of each pet, addressing concerns like obesity or special dietary restrictions.

6. Conclusion

In conclusion, the RFID-based automated pet feeding system represents a significant step forward in enhancing pet care and convenience for pet owners. This innovative system successfully integrates various components, including RFID technology, servo motor control, ultrasonic food level monitoring, GSM communication, and an LCD display, to create a reliable and efficient solution for pet feeding.

The results of our testing demonstrate the system's proficiency in identifying and granting access to authorized pets, ensuring that only registered pets can partake in feeding activities. With a high rate of successful pet identifications, the system's RFID technology plays a pivotal role in ensuring the security and access control of the food bowl.

The servo motor-controlled food bowl lid delivers precise and responsive performance, enabling pets to access their meals promptly and reliably. The system's swift response to approaching pets enhances the user experience and eliminates potential delays in feeding.

While the system's core functionality is commendable, we also identified areas for improvement. The variable connection time of the GSM module suggests that network-related factors can influence communication. Addressing this issue can enhance the timeliness of notifications to pet owners.

Furthermore, the occasional display anomalies during initial power-up and the delay in LCD display updates present opportunities for refinement. Streamlining the initialization sequence and optimizing the code responsible for display updates will ensure a smoother user experience and real-time monitoring of food levels.

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